SMD Missions Current/Past 12 Months

**Astrophysics**
- **Herschel/Plank**
  - Launch: 5/14
- **HST SM4**
  - Launch: 5/11
- **WISE**
  - Launch: 12/14

**Earth Science**
- **GOES-O**
  - Launch: 6/27
- **GOES P**
  - Launch: 3/4

**Heliophysics**
- **MESSENGER**
  - Mercury Flyby: 9/29
- **SDO**
  - Launch: 2/11

**Planetary Science**
- **Cassini Flyby**
  - Titan: 1/28
  - Helene: 3/3

**Timeline:**
- **Apr 2009**
- **May**
- **June**
- **July**
- **Aug**
- **Sept**
- **Oct**
- **Nov**
- **Dec**
- **Jan**
- **Feb**
- **Mar 2010**
### Total Missions / Spacecraft

84 / 98

### Formulation

12 / 12

- JPL
- GSFC
- MSFC

### Implementation

15 / 18

- JPL
- GSFC
- DFRC
- ARC
- JPL

### Primary Ops

19 / 19

- JPL
- GSFC
- MSFC
- LaRC
- JPL

### Extended Ops

38 / 49

- JPL
- GSFC
- MSFC

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**In concept development/pre-formulation:**

- JDEM, SIM-Lite, LISA, Con-X, Mars 2016/ExoMars, Mars 2018, OPF, CLARREO, DESDynl, GRACE FO, SAGE III

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**NOAA Reimbursable:**

- GOES-R, Jason-3 (pre-formulation)

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SOFIA is a mission projects but does not add spacecraft

*Italics* = US instruments on foreign mission

X / Y = # of missions / # of spacecraft

* New missions for Deep Impact and Stardust, respectively

~ Operated by another agency

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**RHESSI SOHO TIMED TRACE WIND ACE GEOTAIL**

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### NOAA Reimbursable:

- GOES-R, Jason-3 (pre-formulation)
NASA Observations of the Eyjafjallajökull Volcano Eruption and Tracking of the Ash Plume

NASA uses its vast array of satellite observations to aid other agencies in the detection and monitoring of the eruption and the aviation hazards caused by volcanic ash. Iceland’s Eyjafjallajökull Volcano burst into life on March 20, 2010. A 2,000-foot long fissure opened in the Fimmvörduháls Pass, accompanied by lava fountains and steam explosions. In mid-April, a huge plume of ash erupted and spread across the North Atlantic, shutting down air traffic in Europe. By April 21st, the eruption had quieted, but some ash emissions continued.

Right: CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) satellite provided a bird's-eye view of the ash cloud's horizontal spread, a unique vertical profile of a slice of the atmosphere. In this image, the ash cloud is seen as a thin, wispy layer of particles ranging in altitude from about 5,000 to 22,000 feet. CALIPSO uses an innovative lidar to see aerosols (small particles such as dust, smoke and pollution) and thin clouds that are often invisible to radar, and to human eye.

Above: ASTER (Terra) data in the visible/near infrared and thermal infrared (TIR) during day time overpasses and in the TIR at night were used in this processed image showing the composition of the plume – silicate ash (red), water vapor (ash) and Ice (blue).
OMI-MODIS Images of Eyjafjallajökull Ash Cloud
GRACE DTECTS UNSUSTAINABLE GROUNDWATER LOSS

Observed trends in groundwater levels, October, 2003 – March, 2009

Pattern of groundwater depletion in NW India

Water Storage Anomaly

Drawdown by 31 km$^3$ (= 1 Lake Mead) in 66 months

Famiglietti et al., 2009

Loss of 109 km$^3$ (3 Lake Meads) over 72 months

Rodell et al., 2009
NASA's New Eye on the Sun Delivers Stunning First Images

NASA's recently launched Solar Dynamics Observatory, or SDO, is returning early images that confirm an unprecedented new capability for scientists to better understand our sun’s dynamic processes. These solar activities affect everything on Earth. Some of the images from the spacecraft show never-before-seen detail of material streaming outward and away from sunspots. Others show extreme close-ups of activity on the sun’s surface. The spacecraft also has made the first high-resolution measurements of solar flares in a broad range of extreme ultraviolet wavelengths.
Martian Ice Found Just below the Surface

- Fresh small impact craters show:
  - Ice layer ~0.5 – 1m below surface
  - Sublimates over several weeks
- Spectral analysis shows ~99% pure water
- Ice more extensive than expected from current climate
- Mars had a wet history

43.3° N 164.2° E

88 days

46.2° N 188.5° E

50 days

35m
NASA’s Wide-field Infrared Survey Explorer, or WISE, has captured its first look at the starry sky that it will soon begin surveying in infrared light.

The infrared image was taken shortly after the space telescope’s cover was removed, exposing the instrument’s detectors to starlight for the first time. The picture shows about 3,000 stars in the Carina constellation.

Launched on Dec. 14, WISE will scan the entire sky for millions of hidden objects, including asteroids, “failed” stars and powerful galaxies. WISE data will serve as navigation charts for other missions, such as NASA’s Hubble and Spitzer Space Telescopes, pointing them to the most interesting targets the mission finds.

NASA’s Kepler space telescope, designed to find Earth-size planets in the habitable zone of sun-like stars, has discovered its first five new exoplanets, or planets beyond our solar system. The new exoplanets are named Kepler 4b, 5b, 6b, 7b and 8b.

The new exoplanets range in size from similar to Neptune to larger than Jupiter, and are known as “hot Jupiters” because of their high masses and extreme temperatures. They have orbits ranging from 3.3 to 4.9 days. Estimated temperatures of the planets range from 2,200 to 3,000 degrees Fahrenheit, hotter than molten lava and much too hot for life as we know it. All five of the exoplanets orbit stars hotter and larger than Earth’s sun.

The discoveries are based on approximately six weeks’ worth of data collected since science operations began on May 12, 2009.
SMD E/PO Programs & Outcomes

• SMD invests about $50M per year on E/PO spread through every SMD program and project.

• SMD’s E/PO Programs come in many sizes
  • Mission E/PO (at least 1% of mission cost)
  • Forums
  • Sponsored and unique activities (GLOBE)
  • PI-led mid-size activities
  • Research supplements

• SMD’s E/PO Programs are aligned with NASA’s Education Portfolio and support:
  • Higher education
  • Elementary/secondary education
  • Informal education
  • Public outreach
• Be responsive to the science community by supporting the priorities established in the NRC Decadal Surveys.

• All missions should be chosen through Decadal Surveys or competitive peer review

• Responsive to national priorities, such as OCO-2

• Per usual SMD practice, each Theme manages within its existing budget envelope, with the exception of minor near-term zero-sum trades (re-phasing) to address pressing issues.

• Projects in development are budgeted to a LCC reflecting a 70% cost confidence (CL) or, more conservatively, a joint-cost-and-schedule confidence (JCL) level.

• SMD is actively refining the cost ranges for projects in formulation to improve budget estimates as these projects make their way through Phases A and B.
SMD Budget by Theme (RY $M)

<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td>Science</td>
<td>$4,903.1</td>
<td>$4,493.3</td>
<td>$5,005.6</td>
<td>$5,248.6</td>
<td>$5,509.6</td>
<td>$5,709.8</td>
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<td>$1,320.7 29%</td>
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<td>Heliophysics *</td>
<td>$607.8</td>
<td>$627.4</td>
<td>$641.9</td>
<td>$647.6</td>
<td>$679.8</td>
<td>$704.4</td>
<td>$750.8</td>
<td>$123.4 20%</td>
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<td>$1,103.9</td>
<td>$1,076.3</td>
<td>$1,109.3</td>
<td>$1,149.1</td>
<td>$1,158.7</td>
<td>$1,131.6</td>
<td>$27.7 3%</td>
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<td>Planetary Science</td>
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<td>$1,341.3</td>
<td>$1,485.7</td>
<td>$1,547.2</td>
<td>$1,591.2</td>
<td>$1,630.1</td>
<td>$1,649.4</td>
<td>$308.1 23%</td>
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<td>Earth Science</td>
<td>$1,702.3</td>
<td>$1,420.7</td>
<td>$1,801.7</td>
<td>$1,944.5</td>
<td>$2,089.5</td>
<td>$2,216.6</td>
<td>$2,282.2</td>
<td>$861.5 61%</td>
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* includes future Astro Explorers
## SMD Total Budget Trace ($M)

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<thead>
<tr>
<th></th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
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<td>4903.0</td>
<td>4477.2</td>
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<td>OCO-2</td>
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<td>91.0</td>
<td>51.0</td>
<td>13.0</td>
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<td>Climate Initiative</td>
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<td>309.0</td>
<td>449.0</td>
<td>587.0</td>
<td>646.0</td>
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<td>Near Earth Object Observations</td>
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<tr>
<td>Reductions for Agency issues (CM&amp;O, etc.)</td>
<td>-35.1</td>
<td>-54.1</td>
<td>-71.1</td>
<td>-87.1</td>
<td>-103.4</td>
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<tr>
<td>IT Infrastructure: transfer without impact</td>
<td>-3.3</td>
<td>-4.2</td>
<td>-4.3</td>
<td>-4.5</td>
<td>-4.7</td>
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<tr>
<td>CoF transfers</td>
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<td>-40.4</td>
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<tr>
<td>FY10 Appropriation (net of all changes)</td>
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<td></td>
<td>16.1</td>
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### FY11 President's Budget

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<tr>
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<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
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<tbody>
<tr>
<td>FY11 President's Budget</td>
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<td>4493.3</td>
<td>5005.6</td>
<td>5248.6</td>
<td>5509.6</td>
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</tbody>
</table>
FY2011 Budget Request: Earth Science

• Present infusion enables significant mission accelerations and program expansions
  • OCO-2 development and launch by 2/2013
  • Accelerates selected Decadal Survey systematic missions, launching all 4 Tier-1 missions between 2014 and 2017
• Expands and accelerates Venture-class competitive, PI-led program
  • ANNUAL solicitations for major flight instruments PLUS biannual alternating airborne and small-mission solicitations
  • First small-sat selections in 2012
• Develops selected Climate Continuity Missions
  • SAGE-III refurbishment/hexapod development, ready for flight to ISS late CY2013
  • GRACE-FO (GRACE Follow-on), launch late CY2015 (joint with DLR)
• Enables key non-flight activities
• With US Global Change Research Program, identifies and enables additional selected Tier-2 Decadal Survey missions to be developed for flight in 2019-2020 time frame
Mission Launch Cadence – Earth FY11 Budget

- GLORY (11/2010)
- Aquarius (12/2010) (with CONAE)
- NPP (NET 9/2011) (with Interagency partners)
- LDCM (12/2012) (agency external commitment 6/2013) (with USGS, TIRS capability)
- OCO-2 (2/2013)
- GPM Core (7/2013) (with JAXA)
  - SAGE-III on ISS (11/2013) (launch required, includes hexapod)
  - SMAP (11/2014) (date set by LV selection issues, SRB’s recommendation for Phase C-D)
  - ICESAT-2 (10/2015) (date constrained by technical development)
  - GRACE-C (12/2015) (likely with DLR; budgeted for well over grass-roots estimate)
  - CLARREO-1 (10/2017) (cost-constrained mission)
  - DESDynI RADAR+LIDAR (10/2017) (possibly with DLR, partnership not essential)
  - Additional missions possible for launch prior to 2020, identified in concert with USGCRP

- Annual Venture major instrument solicitations starting in FY12
- First small-sat Venture mission call in FY12
FY2011 Budget Request: Heliophysics

• Enable a robust schedule of small, medium and flagship mission launches, funded to a 70% confidence level, to achieve the vision for Heliophysics set forth in the 2003 NRC Decadal Survey.

• Develop and launch SDO and RBSP, the first two missions in the LWS Program, with the goal of creating a predictive capability for space weather.

• Continue formulation and development of MMS, the number one priority moderate class mission and Solar Probe Plus, the number one priority large class mission in the Decadal Survey.

• Preserve the availability of Explorer Program missions to provide frequent, low cost flight opportunities that target focused science topics and fill important science gaps in Heliophysics and Astrophysics.

• Based on the FY2010 Senior Review, continue to fund existing mission operations to achieve maximum science return.

• Maintain robust Research Program (including competitively selected science investigations, suborbital program, supporting research and technology and science data archiving and computing) and E/PO Program.
FY2011 Budget Request: Planetary Science

• Pursue partnership with ESA for Mars Program & OPF based on shared interests and common goals

• Accommodate new liens without mission cancelations/delays:
  • MAVEN ELV
  • MSL launch vehicle acceleration and added funding for the 2011 LRD to resolve MSL technical problems with the actuators, avionics and the titanium

• Prepare for potential rebalancing of priorities based on the Planetary Science Decadal Survey coming in 2011

• Ensure specific technology programs can support expected future missions (e.g.: ASRG etc.)

• Maintain Planetary R&A program and operating missions

• Supports selection of next New Frontiers mission in FY11 (candidate missions under study include NEO sample return, Lunar sample return, Venus Lander)
FY2011 Budget Request: Astrophysics

• Fund missions in development phase, including JWST, SOFIA, NuSTAR, Astro-H, and GEMS

• Reflect results of Senior Review for Operating Missions, scheduled for April 2010, in support of missions in extended science phase during FY2011 and beyond

• Respond to Astrophysics Decadal Survey results, due to be released late-summer 2010 (technology investments and future mission lines)
  • Engage in strategic technology investments and portfolio roadmapping
  • Negotiate relevant interagency/international collaborations for future mission initiatives
  • Identify relevant mechanisms and schedule for selecting investigations based on decadal priorities
### NASA Science Mission Launches (Fiscal Years 2010-20)

**As of 4/16/10**

For planning purposes only

<table>
<thead>
<tr>
<th>Year</th>
<th>Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>WISE, SOFIA*, SDO, GOES-P</td>
</tr>
<tr>
<td>2011</td>
<td>Glory, NPP, Juno, GRAIL</td>
</tr>
<tr>
<td>2012</td>
<td>NuSTAR, RBSP, LWS SET-1</td>
</tr>
<tr>
<td>2013</td>
<td>LDCM, OCO-2, IRIS, MSL</td>
</tr>
<tr>
<td>2014</td>
<td>SAGE III, MAVEN, GEMS</td>
</tr>
<tr>
<td>2015</td>
<td>JWST, SAGE III, IRIS, MSL</td>
</tr>
<tr>
<td>2016</td>
<td>Discovery-12, ICESat-2</td>
</tr>
<tr>
<td>2018</td>
<td>CLARREO-1, DESDynI, New Front 3</td>
</tr>
<tr>
<td>2019</td>
<td>MMS, Solar Orbiter, ESA/NASA Mars 2016, Venture 2</td>
</tr>
<tr>
<td>2020</td>
<td>JEO, ES Tier 2-1, ES Tier 2-2</td>
</tr>
</tbody>
</table>

- ✔ = NASA Mission on US ELV
- ✓ = Mission successfully launched
- Red Text = new or accelerated in FY11 Budget Request
- Red Text = Early science flights begin
- Red Text = Reimbursable for NOAA
- Purple = International Mission with Substantial NASA Contribution